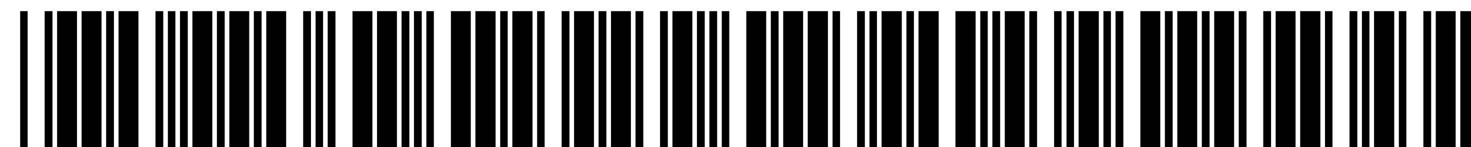

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(54) **SAMPLE STRUCTURE ANALYZING METHOD, TRANSMISSION ELECTRON MICROSCOPE, AND COMPUTER-READABLE NON-TRANSITORY RECORDING MEDIUM**

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G01N 23/20 (2006.01)

(52) **U.S. Cl.**
CPC ***G01N 23/20058*** (2013.01); ***H01J 37/26*** (2013.01)
USPC **250/307**; 250/306; 250/311

(58) **Field of Classification Search**
USPC 250/306, 307, 311
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,211,924 A * 7/1980 Muller et al. 250/311
4,553,030 A 11/1985 Tokiwai et al.
4,880,977 A * 11/1989 Tomita et al. 250/311
5,350,921 A * 9/1994 Aoyama et al. 250/311
5,466,934 A * 11/1995 Adams et al. 250/307
5,576,543 A * 11/1996 Dingley 250/311
5,744,800 A * 4/1998 Kakibayashi et al. 250/311
7,928,377 B2 * 4/2011 Ishitani et al. 250/306
8,008,621 B2 * 8/2011 Jeong et al. 250/307
8,253,099 B2 * 8/2012 Nicolopoulos et al. 250/307
8,476,588 B2 * 7/2013 He et al. 250/307
2003/0234359 A1 * 12/2003 Drown et al. 250/307
2004/0188610 A1 * 9/2004 Hirose 250/310
2010/0019145 A1 * 1/2010 Jeong et al. 250/307
2011/0284744 A1 * 11/2011 Zewail et al. 250/307
2012/0025073 A1 * 2/2012 Kumar 250/307

FOREIGN PATENT DOCUMENTS

JP 2007-064962 A 3/2007
JP 2010-256261 A 11/2010
JP 2011-021926 A 2/2011

* cited by examiner

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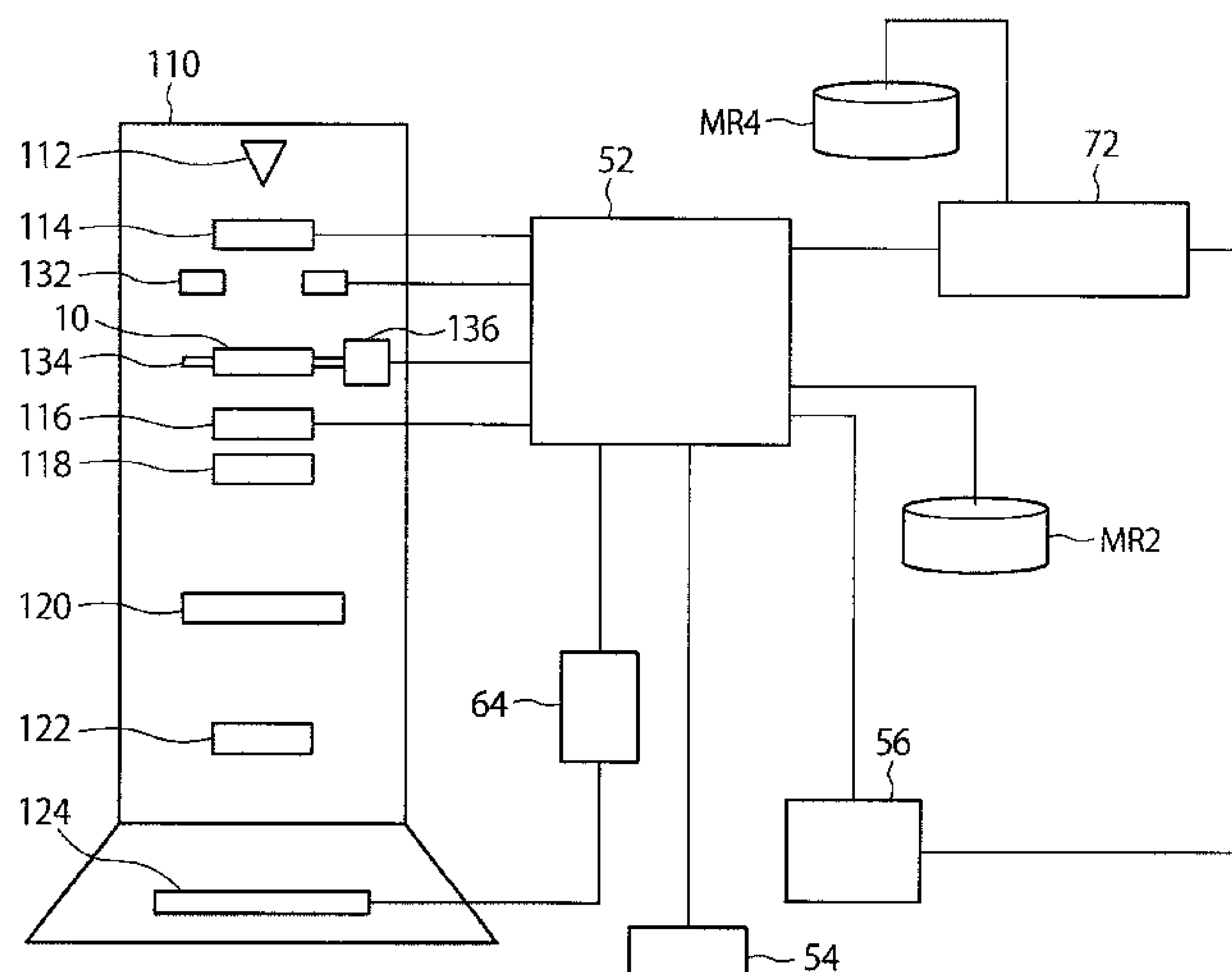
(57) **ABSTRACT**

In accordance with an embodiment, a sample structure analyzing method includes generating a beam and then applying the beam to a plurality of observation regions on a sample, and acquiring a plurality of diffraction images from the beam which has passed through the sample; and comparing the acquired diffraction images, and judging the difference between the observation regions from the comparison result, or identifying the grain boundary of crystal constituting the sample.

16 Claims, 6 Drawing Sheets



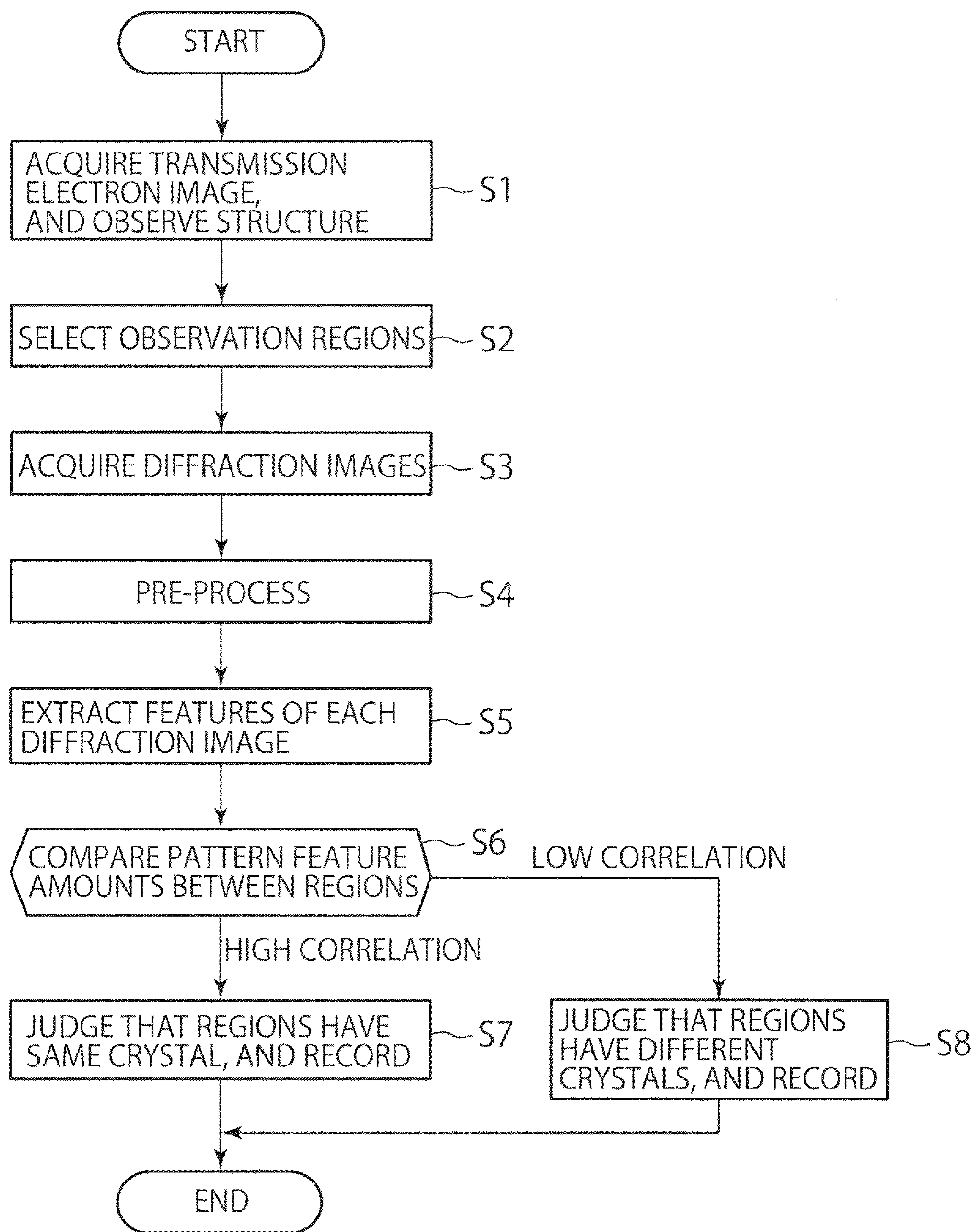


FIG. 1

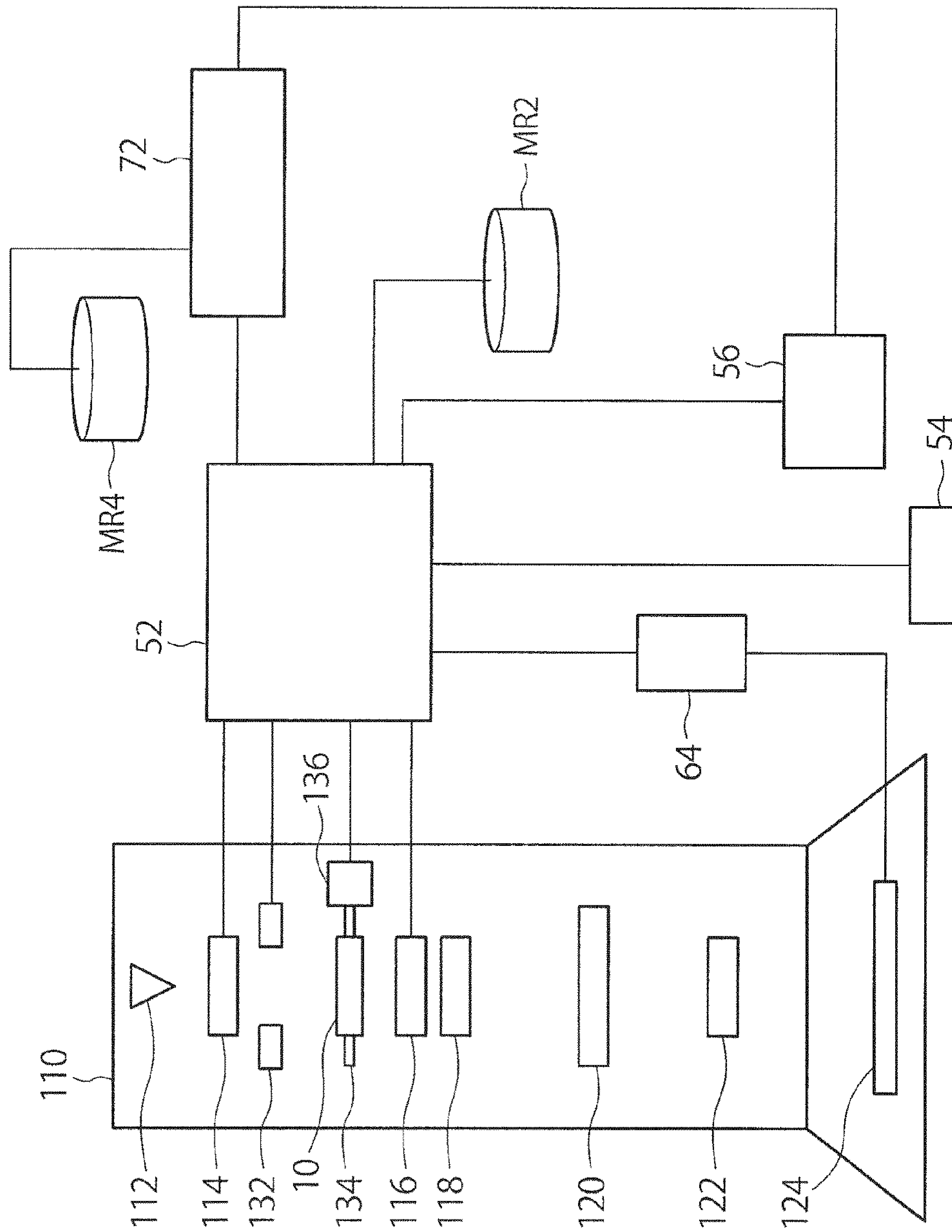


FIG. 2

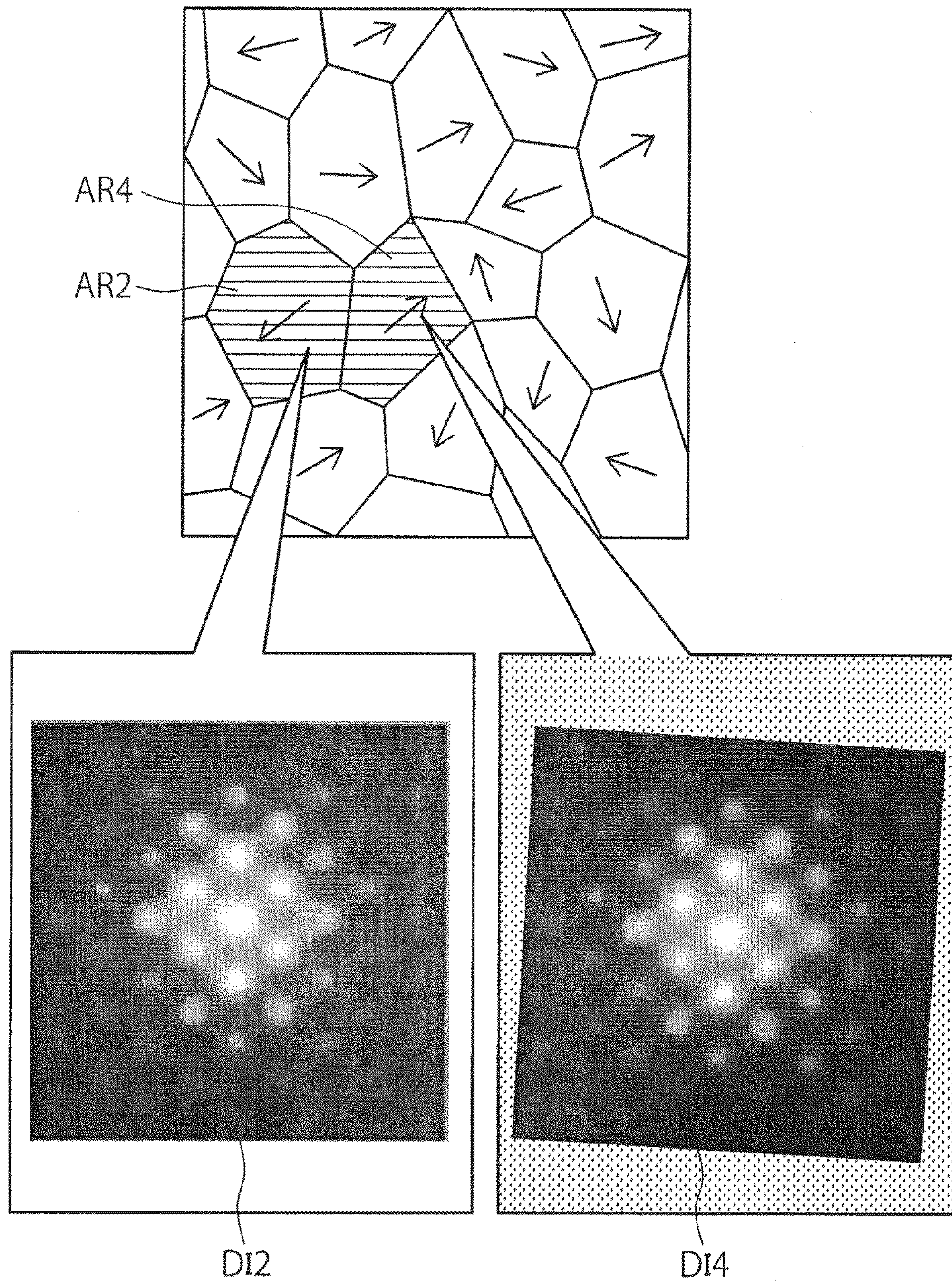


FIG. 3

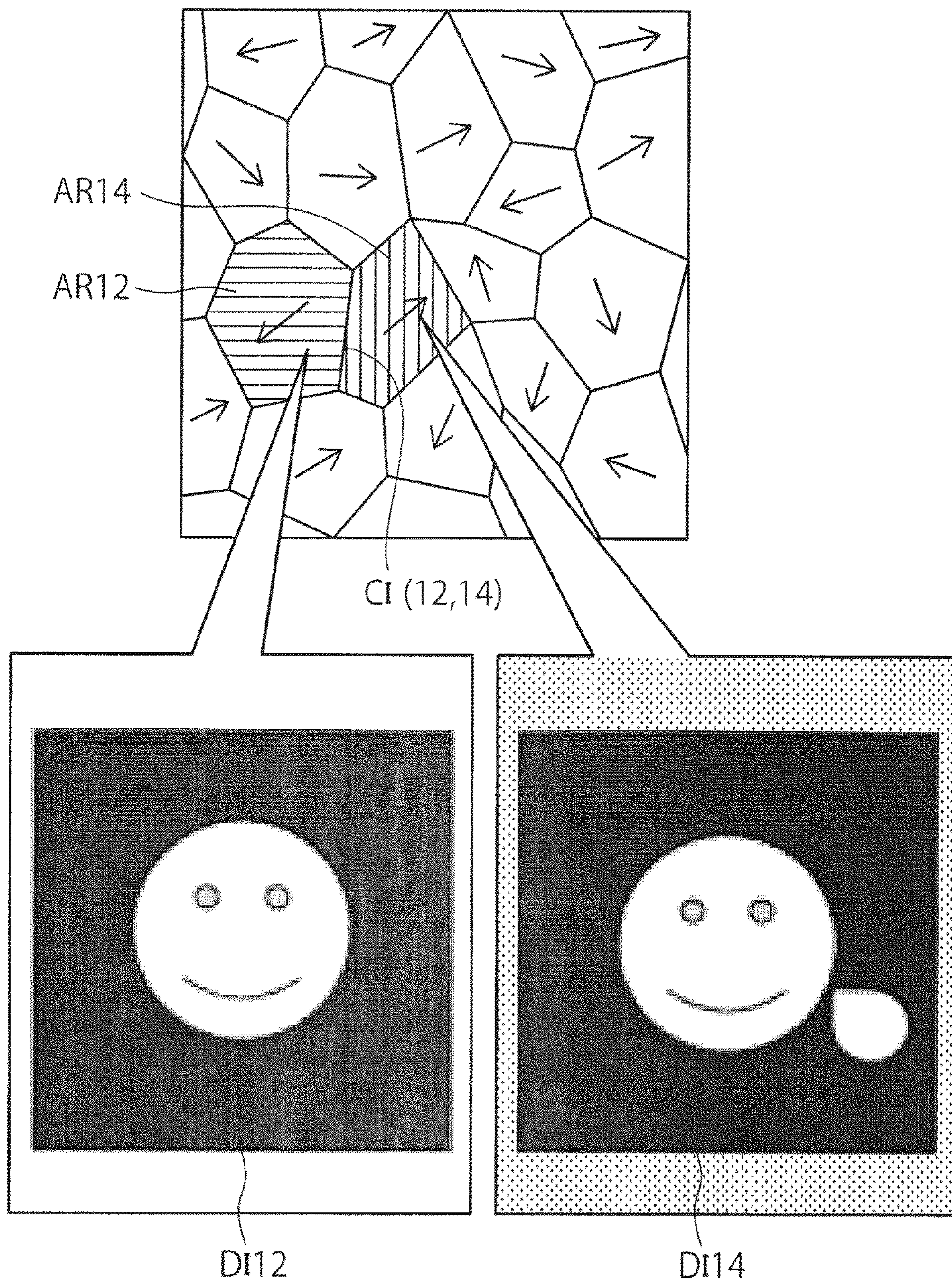


FIG. 4

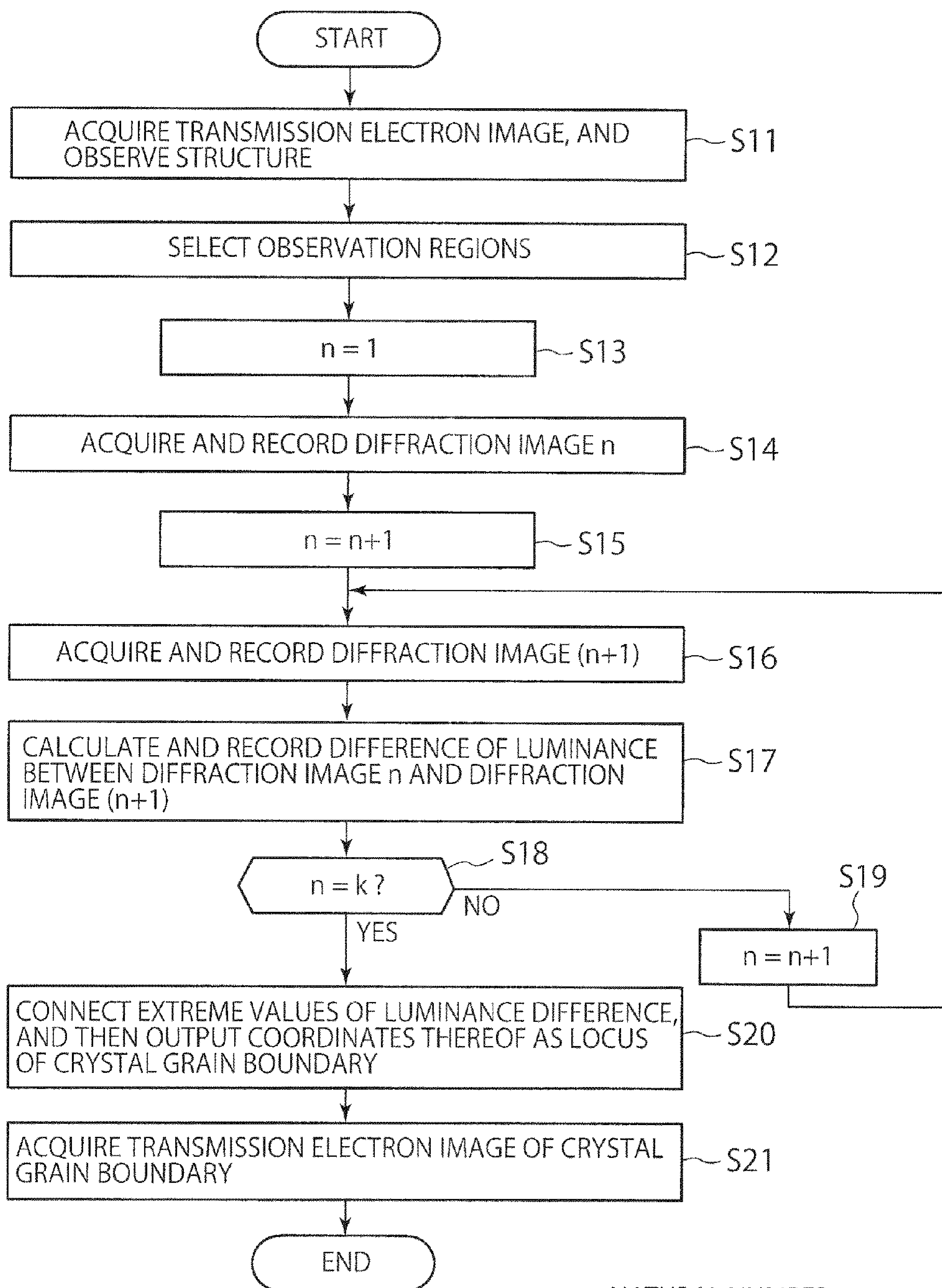


FIG. 5

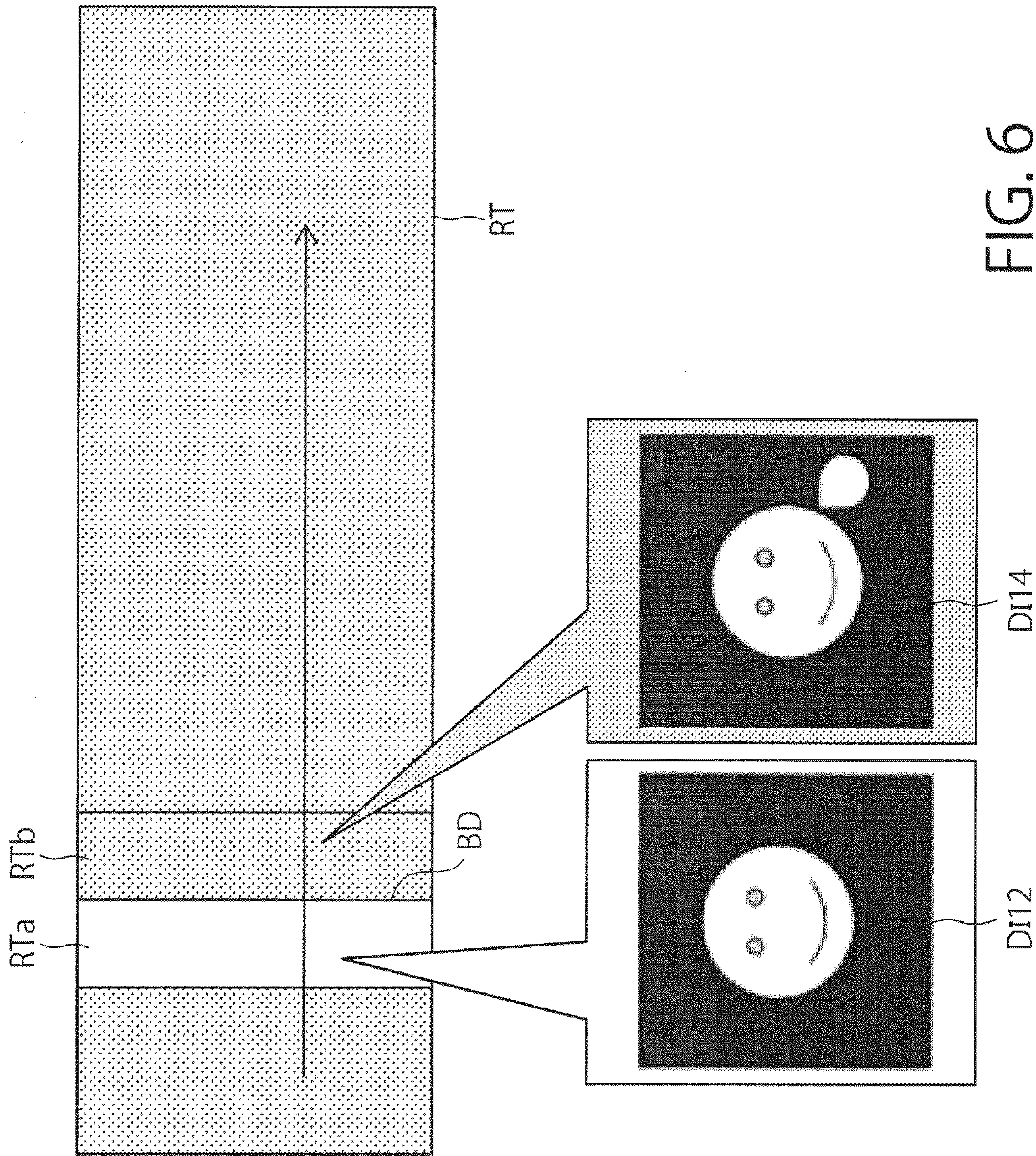


FIG. 6

SAMPLE STRUCTURE ANALYZING METHOD, TRANSMISSION ELECTRON MICROSCOPE, AND COMPUTER-READABLE NON-TRANSITORY RECORDING MEDIUM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2013-122927, filed on Jun. 11, 2013, the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to a sample structure analyzing method, a transmission electron microscope, and a computer-readable non-transitory recording medium.

BACKGROUND

There has been known a technique for applying an electron beam to a thin film sample by using a transmission electron microscope, detecting the electron beam which has passed through the thin film sample to acquire a plurality of electron images, and comparing contrast between the obtained electron images to observe the sample structure.

However, for example, even if the electron images are acquired over a crystal grain boundary, a contrast difference cannot be well observed in some cases. In such cases the technique of judging by the contrast of the transmission electron image causes problems in the identification of the crystal grain boundary and the measurement of a shape.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a flowchart showing the general procedure of a sample structure analyzing method according to Embodiment 1;

FIG. **2** is a block diagram showing the general configuration of a transmission electron microscope for conducting the sample structure analyzing method according to Embodiment 1;

FIG. **3** is a diagram showing an example of diffraction images obtained from two regions different in crystal orientation;

FIG. **4** is a schematic diagram illustrating diffraction images obtained from two regions different in material and crystal orientation;

FIG. **5** is a flowchart showing the general procedure of a sample structure analyzing method according to Embodiment 2; and

FIG. **6** is a diagram illustrating the technical meaning of extreme values calculated by the sample structure analyzing method according to Embodiment 2.

DETAILED DESCRIPTION

In accordance with an embodiment, a sample structure analyzing method includes generating a beam and then applying the beam to a plurality of observation regions on a sample, and acquiring a plurality of diffraction images from the beam which has passed through the sample; and comparing the acquired diffraction images, and judging the difference

between the observation regions from the comparison result, or identifying the grain boundary of crystal constituting the sample.

Embodiments will now be explained with reference to the accompanying drawings. Like components are provided with like reference signs throughout the drawings and repeated descriptions thereof are appropriately omitted.

The drawings are attached to illustrate the invention and assist in the understanding of the illustration. Therefore, the shapes, dimensions, and ratios in some parts may be different from those in an actual apparatus, but can be properly designed and modified by reference to the following explanations and known arts. Although an electron beam is described as an example of a beam in the present specification, the beam is not limited thereto and is also applicable to other charged particle beams such as an ion beam.

(1) Embodiment 1

A schematic procedure of a sample structure analyzing method according to Embodiment 1 is described with reference to a flowchart in FIG. **1**.

First, an electron beam is generated and then applied to a sample. A transmission electron image is acquired from the transmitted electron beam, and the general structure of the sample is observed (step S**1**).

A plurality of observation regions are selected as regions of interest from the observation result in step S**1** (step S**2**).

The electron beam is then applied to each of the selected observation regions for each predetermined pitch, and a plurality of diffraction images are acquired (step S**3**).

The obtained diffraction images are pre-processed for the subsequent processing. More specifically, multivalued images are converted to two-value images by two-dimensional filtering such as noise elimination, smoothing, and sharpening (digitalization).

Feature amounts of each of the digitalized diffraction images are then extracted (step S**5**). The feature amounts are compared between the observation regions, and the degree of correlation between the diffraction images is judged (step S**6**).

When the correlation between the observation regions is high, these regions are judged to be regions having the same crystal, and the judgment result is recorded together with information on the regions (step S**7**).

On the other hand, when the correlation is low, the crystals are judged to be different in at least one of material and crystal orientation, and the judgment result is recorded together with information on the regions (step S**8**).

FIG. **2** is a block diagram showing the general configuration of a transmission electron microscope for conducting the sample structure analyzing method according to Embodiment 1. The transmission electron microscope shown in FIG. **2** includes a main unit **110**, a control unit **52**, an input unit **54**, a monitor **56**, a signal processing unit **64**, and an image analyzing unit **72**.

The main unit **110** includes an electron gun **112**, a condensing lens **114**, a deflector **132**, a sample holder **134**, an actuator **136**, an objective lens **116**, a limiting field stop **118**, an intermediate lens **120**, a projection lens **122**, and a fluorescent screen **124**. These components are disposed in a column. The main unit **110** is coupled to an unshown high-vacuum pump, and is used after the column has been vacuumized.

A sample **10** is a thin film sample which is extracted from a device to be observed and which is produced by fabricating to such a thickness as to allow the transmission of electro-

magnetic radiations. The sample **10** is held on the sample holder **134** and located between the condensing lens **114** and the objective lens **116**.

The sample holder **134** is coupled to the actuator **136**. When the actuator **136** operates in accordance with a control signal sent from the control unit **52**, the sample holder **134** moves the sample **10** in an X-Y two-dimensional plane, or inclines the sample **10** at a given angle of inclination. In the present embodiment, the actuator **136** corresponds to, for example, a sample moving unit.

The deflector **132** deflects the electron beam at a given deflection angle when a control signal is sent from the control unit **52**, and the sample **10** is thereby scanned.

The input unit **54** is an interface for an operator to input, to the control unit **52**, various parameters necessary for the observation of the sample **10**, such as optical conditions of the main unit **110**, information regarding the observation region selected to acquire the diffraction image, and threshold data to judge the degree of correlation between the diffraction images.

The image analyzing unit **72** extracts feature amounts from the diffraction images respectively acquired in the different observation regions, and then compares the feature amounts with a predetermined threshold input from the input unit **54**. The image analyzing unit **72** thereby judges whether the observation regions are made of crystal of the same material and crystal of the same orientation, or identifies a crystal grain boundary from the difference of the feature amounts. A memory MR4 is connected to the image analyzing unit **72**. Data on the judgment result and the identification result are stored in the memory MR4.

The image analyzing unit **72** is connected to the monitor **56**. The above-mentioned judgment result and identification result can be displayed by the monitor **56**.

In the present embodiment, the image analyzing unit **72** corresponds to, for example, an analyzing unit.

The electron beam emitted from the electron gun **112** is condensed by the condensing lens **114**, and deflected by the deflector **132**, and then passes through the sample **10** while scanning the sample **10**. The electron beam which has passed through the sample **10** enters the fluorescent screen **124** via the objective lens **116**, the limiting field stop **118**, the intermediate lens **120**, and the projection lens **122**. An electron microscope image or a diffraction image of the sample **10** is formed on the fluorescent screen **124**, and photoelectrically transformed so that a signal is sent to the signal processing unit **64**.

The signal processing unit **64** is connected to the control unit **52**. The signal processing unit **64** processes a signal sent from the fluorescent screen **124** to form an electron microscope image or a diffraction image, and sends the image to the control unit **52**. The control unit **52** stores the electron microscope image or diffraction image of the sample **10** in a memory MR2, and also displays the image on the monitor **56** so that the operator can observe the image.

In the present embodiment, the electron gun **112** and the condensing lens **114** correspond to, for example, a beam applying unit. The deflector **132**, the actuator **136**, the objective lens **116**, the limiting field stop **118**, the intermediate lens **120**, the projection lens **122**, the fluorescent screen **124**, the signal processing unit **64**, and the control unit **52** correspond to, for example, a diffraction image acquiring unit.

A more specific processing procedure of the sample structure analyzing method according to Embodiment 1 using the transmission electron microscope shown in FIG. **2** is described with reference to FIG. **3** and FIG. **4**.

First, for the observation of the general structure of the sample **10**, a low-magnification transmission electron image is acquired and displayed on the monitor **56**. The operator watches the transmission electron image displayed on the monitor **56**, and selects a plurality of observation regions where a structural analysis should be conducted, and then inputs, from the input unit **54**, data to specify the selected observation regions.

A magnification is then set in such a manner that the selected observation regions come into view, and a diffraction image of each of the observation regions of the sample **10** is acquired. More specifically, the control unit **52** supplies a control signal to the condensing lens **114** to adjust a beam flux, and also supplies a control signal to the deflector **132** to adjust an irradiation pitch. The actuator **136** moves the sample **10** in the X-Y two-dimensional plane, and the observation regions of the sample **10** are scanned with the electron beam in the meantime. The irradiation pitch is set in accordance with the size of crystal constituting the sample **10**. For example, a pitch of several nm is set.

FIG. **3** is a schematic diagram showing an example of selected observation regions, and shows an example of diffraction images acquired from the respective observation regions. Diffraction images DI2 and DI4 in FIG. **3** are obtained by scanning observation regions AR2 and AR4 with the electron beam, respectively.

In the schematic diagram of the observation regions shown in the upper part of FIG. **3**, the observation regions AR2 and AR4 are made of the same material, but have opposite crystal orientations as indicated by arrows. Therefore, the diffraction images DI2 and DI4 in the lower part of FIG. **3** are slightly different in contrast.

To analyze the structure of the sample **10**, features of the diffraction images DI2 and DI4 are extracted by the image analyzing unit **72**. More specifically, a pattern edge of each diffraction image is extracted by, for example, Hough transform, and its geometrical features are extracted. Specific examples of the geometrical features include, for example, the distance between characteristic parts in the diffraction image, the area of each diffraction image, barycentric coordinates, and central coordinates.

The image analyzing unit **72** then performs pattern matching between the diffraction images DI2 and DI4, calculates a matching score (the degree of correspondence), and compares the obtained matching score with a predetermined threshold. If the matching score is more than the predetermined threshold, the degree of correlation between the observation regions AR2 and AR4 is high, and these observation regions are judged to be regions having the same crystal structure. The judgment result is displayed on the monitor **56** and stored in the memory MR4. On the other hand, if the matching score is equal to or less than the predetermined threshold, the degree of correlation between the observation regions AR2 and AR4 is low, and these observation regions are judged to be regions having different crystal structures. The judgment result is displayed on the monitor **56** and stored in the memory MR4.

The threshold is not limited to a single threshold. For example, it is possible to prepare and use a first threshold to judge whether crystal orientations are the same even if the material is the same, and a second threshold to judge whether materials are different.

FIG. **4** shows a schematic diagram of another example of selected observation regions, and a schematic diagram of diffraction images obtained from the respective observation regions. Diffraction images DI12 and DI14 represent images

obtained by scanning observation regions AR12 and AR14 with the electron beam, respectively.

In the schematic diagram of the observation regions shown in the upper part of FIG. **4**, the observation regions AR12 and AR14 have opposite crystal orientations as indicated by arrows, and are made of different materials. As a result, the diffraction images DI12 and DI14 obtained from these regions are apparently different as schematically shown in the lower part of FIG. **4**. In the case shown in FIG. **4**, the degree of correlation between the observation regions AR12 and AR14 can be detected by a threshold lower than the threshold used in FIG. **3**.

Thus, the lower threshold is first used to classify the observation regions by whether their constituent materials are the same or different, and then the higher threshold is used. It is thereby possible to classify the observation regions made of the same material by whether their crystal orientations are the same or different.

The sample structure analyzing method according to the present embodiment compares a plurality of diffraction images acquired from the beam which has passed through the sample, and judges the difference between the observation regions from the comparison result. Consequently, it is possible to accurately distinguish parts that have little contrast in the transmission electron image only; for example, an interface of an amorphous layer, or an interface between heavy elements.

The transmission electron microscope according to the present embodiment includes analyzing unit for comparing a plurality of diffraction images acquired from the beam which has passed through the sample, and judging the difference between the observation regions from the comparison result. Consequently, it is possible to accurately distinguish parts that have little contrast in the transmission electron image only.

(2) Embodiment 2

A schematic procedure of a sample structure analyzing method according to Embodiment 2 is described with reference to a flowchart in FIG. **5**.

First, as in Embodiment 1, an electron beam is generated and then applied to a sample. A transmission electron image is acquired from the transmitted electron beam, and the general structure of the sample is observed (step S**11**).

A plurality of observation regions are then selected from the observation result in step S**11** (step S**12**). In the present embodiment, there are k (k is a natural number equal to or more than 2) observation regions.

n (n is a natural number) is set to 1 (step S**13**), and then the electron beam is applied to the observation region 1 (n=1) in the form of a line or a dot pattern. A diffraction image n (n=1) is acquired and recorded (step S**14**). The obtained diffraction image n has positional information and luminance information for each pixel. Thus, if the luminance information is considered as a value on a Z-axis, the diffraction image can be represented by (X, Y, luminance) three-dimensional coordinates.

n is then increased to n=n+1 (step S**15**), and the electron beam is applied to an observation region 2 (n=2) adjacent to the observation region 1 in the form of a line or a dot pattern, and then a diffraction image 2 (n=2) is acquired and recorded (step S**16**).

When the diffraction images 1 and 2 are acquired, the difference of luminance between the diffraction images 1 and 2 is calculated and recorded (step S**17**).

As described above, the diffraction images are acquired from the respective neighboring observation regions, and then the difference of luminance therebetween is calculated and recorded. This procedure is repeated to the last observation region, that is, until n=k (steps S**18** and S**19**, steps S**16** and S**17**).

When the luminance differences between the diffraction images are calculated for all the observation regions (YES in step S**18**), the recorded luminance difference is differentiated by a luminance value to find extreme values. If the obtained extreme values are connected, a series of coordinates of the connected extreme values will be a locus of a crystal grain boundary (step S**20**).

Finally, the sample **10** is scanned while the electron beam is being deflected in such a manner that the locus of the crystal grain boundary will be the center of each scan line. A transmission electron image of the crystal grain boundary is thereby acquired (step S**21**).

A more specific processing procedure of the sample structure analyzing method according to Embodiment 2 is more specifically described. In the present embodiment as well, the transmission electron microscope shown in FIG. **2** can be used to analyze the sample structure.

First, as in Embodiment 1 described above, for the observation of the general structure of the sample **10**, a low-magnification transmission electron image is acquired, and displayed on the monitor **56**. The operator watches the transmission electron image displayed on the monitor **56**, and selects a plurality of observation regions where a structural analysis should be conducted, and then inputs, from the input unit **54**, data to specify the selected observation regions.

A magnification is then set by the control unit **52** in such a manner that the selected observation regions come into view. A control signal is sent to the main unit **110**, and a diffraction image n (n=1 to k) of each of the observation regions of the sample **10** is obtained accordingly. Whenever the diffraction image is acquired, its image data is stored in the memory MR2.

The image data regarding the diffraction image n (n=1 to k) is sent to the image analyzing unit **72** via the control unit **52**, and is transformed into three-dimensional coordinate data (X, Y, luminance). The difference of luminance between the diffraction images is then calculated, and stored in the memory MR4

When diffraction images n are then acquired for all the observation regions (n=k) and all the luminance differences between these diffraction images are calculated, extreme values of the luminance difference are found by the image analyzing unit **72**. Then the coordinates of the pixels that provide the obtained extreme values are connected, displayed on the monitor **56** as a locus of a crystal grain boundary, and stored in the memory MR4.

FIG. **6** is a diagram schematically showing how the extreme values of the luminance difference are found. A rectangular region RT in the upper part schematically represents data regarding the luminance difference between the diffraction images. In FIG. **6** the data are recorded from left to right. An arrow in the drawing represents the calculation to find the extreme values of the luminance difference. A boundary BD between data regions RTa and RTb corresponds to one extreme value. This boundary BD corresponds to, for example, a crystal grain boundary CI (**12**, **14**) between the regions AR12 and AR14 in FIG. **4**.

Thus, according to the present embodiment, the luminance difference between the diffraction images is differentiated to find extreme values, and the coordinates of the pixels that

provide the obtained extreme values are connected. Therefore, a locus of a crystal grain boundary can be rapidly found by calculation processing.

When the locus of the crystal grain boundary identified by the process described above is used to scan the sample **10** with the electron beam in such a manner that the locus of the crystal grain boundary will be the center of each scan line, a transmission electron image of the crystal grain boundary can be acquired. This is possible if, for example, a locus of a crystal grain boundary is extracted from the memory MR4 by the control unit **52** of the transmission electron microscope shown in FIG. **2** and a control signal is generated and sent to the deflector **132** and the actuator **136**.

The sample structure analyzing method according to at least one of the embodiments described above has the steps of comparing a plurality of diffraction images acquired from a beam which has passed through a sample, and judging the difference between the observation regions from the comparison result, or identifying the grain boundary of crystal constituting the sample. Consequently, it is possible to accurately distinguish crystal grain faces that would be difficult to distinguish by contrast comparison between images, and it is also possible to find a locus of a crystal grain boundary.

The transmission electron microscope according to at least one of the embodiments described above has analyzing unit for comparing a plurality of diffraction images acquired from a beam which has passed through a sample, and judging the difference between the observation regions from the comparison result, or identifying the grain boundary of crystal constituting the sample. Consequently, it is possible to accurately distinguish crystal grain faces which would be difficult to distinguish by contrast comparison between images, and it is also possible to find a locus of a crystal grain boundary.

(3) Program

A series of procedures in the sample structure analysis described above may be incorporated in a program, and read into and executed by a computer. This enables a series of procedures in the sample structure analysis according to Embodiments 1 and 2 to be carried out by use of a general-purpose computer connected to the main unit of the transmission electron microscope. A series of procedures of the sample structure analysis described above may be stored in a recording medium such as a flexible disk or a CD-ROM as a program to be executed by the computer connected to the main unit of the transmission electron microscope, and read into and executed by the computer.

The recording medium is not limited to a portable medium such as a magnetic disk or an optical disk, and may be a fixed recording medium such as a hard disk drive or a memory. The program incorporating the series of procedures of the sample structure analysis described above may be distributed via a communication line (including wireless communication) such as the Internet. Moreover, the program incorporating the series of procedures of the sample structure analysis described above may be distributed in an encrypted, modulated or compressed state via a wired line or a wireless line such as the Internet or in a manner stored in a recording medium.

The program according to at least one of the embodiments described above has the procedure for comparing a plurality of diffraction images acquired from a beam which has passed through a sample, and judging the difference between the observation regions from the comparison result, or identifying the grain boundary of crystal constituting the sample. Consequently, it is possible to accurately distinguish crystal grain boundaries and regions which would be difficult to distinguish by contrast comparison between images.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions.

For example, the scanning transmission electron microscope (STEM) capable of scanning with the electron beam is shown in the embodiments described above, but the present invention is not limited thereto. For example, the sample analyzing method according to the embodiments described above can also be conducted by use of a transmission electron microscope (TEM) which includes a sample moving mechanism such as the actuator **136** shown in FIG. **2**.

Indeed, the novel methods and systems described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

The invention claimed is:

1. A sample structure analyzing method comprising:

generating a beam and then applying the beam to a plurality of observation regions on a sample, and acquiring a plurality of diffraction images from the beam which has passed through the sample; and

comparing the acquired diffraction images, and judging the difference between the observation regions from the comparison result, or identifying the grain boundary of crystal constituting the sample.

2. The method of claim **1**,

wherein the difference between the observation regions is judged by extracting feature amounts of each of the diffraction images, and comparing the feature amounts between the diffraction images by use of a predetermined threshold.

3. The method of claim **2**,

wherein extracting the feature amounts comprises extracting a pattern edge of each diffraction image, and

comparing the feature amounts comprises performing pattern matching between the diffraction images to calculate a matching score, and comparing obtained matching score with the threshold.

4. The method of claim **3**,

wherein when the matching score is more than the threshold, judgment is made that the correlation between the diffraction images is high, and that the corresponding observation regions are regions of the same crystal, and

wherein when the matching score is equal to or less than the threshold, judgment is made that the correlation between the diffraction images is low, and that the corresponding observation regions are regions of crystal different in at least one of material and crystal orientation.

5. The method of claim **2**,

wherein the threshold comprises

a first threshold to judge whether materials are the same and whether crystal orientations are the same, and

a second threshold to judge whether materials are different.

6. The method of claim **1**,

wherein the diffraction images are composed of pixels comprising luminance information, and

identifying the crystal grain boundary comprises

finding the difference of luminance value between the diffraction images, and differentiating obtained luminance difference to obtain extreme values, and

obtaining a locus of the crystal grain boundary from the extreme values.

7. The method of claim **6**, further comprising:

scanning the sample with the beam in such a manner that scanning area comprises the locus of the crystal grain boundary, and thereby acquiring a transmission electron image of the crystal grain boundary.

8. The method of claim **1**, further comprising:

generating a beam and then applying the beam to a sample, and acquiring a transmission electron image from the beam which has passed through the sample,

wherein the observation regions are selected in accordance with obtained transmission electron image.

9. The method of claim **1**,

wherein the diffraction images are acquired by scanning the sample with the beam.

10. The method of claim **1**,

wherein the beam is applied for each pitch which corresponds to a size of crystal constituting the sample.

11. A transmission electron microscope comprising:

a beam applying unit configured to generate a beam and apply the beam to a sample;

a diffraction image acquiring unit configured to acquire a diffraction image from each of a plurality of observation regions of the sample from the beam which has passed through the sample; and

an analyzing unit configured to compare the acquired diffraction images, and judge difference between the observation regions from the comparison result, or identify the grain boundary of crystal constituting the sample.

12. The microscope of claim **11**,

wherein the analyzing unit judges the difference between the observation regions by extracting feature amounts of each of the diffraction images, and by comparing the feature amounts between the diffraction images by use of a predetermined threshold.

13. The microscope of claim **11**,

wherein the diffraction images are composed of pixels comprising luminance information, and

the analyzing unit identifies the crystal grain boundary by finding the difference of luminance value between the diffraction images, differentiating obtained luminance difference to find extreme values, and obtaining a locus of the crystal grain boundary from the extreme values.

14. The microscope of claim **11**, further comprising:

a beam deflecting unit configured to deflect the beam to scan the sample.

15. The microscope of claim **11**, further comprising:

a sample moving unit configured to move the sample to scan the sample with the beam.

16. A computer-readable non-transitory recording medium containing a program which causes a computer controlling a transmission electron microscope to execute a sample structure analysis, the sample structure analysis comprising:

generating a beam and then applying the beam to a plurality of observation regions on a sample, and acquiring a plurality of diffraction images from the beam which has passed through the sample; and

comparing the acquired diffraction images, and judging the difference between the observation regions from the comparison result, or identifying the grain boundary of crystal constituting the sample.

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